Chapter 3: HISTORY AND CURRENT STATUS OF FISH POPULATIONS

Anadromous fish of sport and commercial value using the Chehalis Basin are spring- and fall-run chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), winter and summer run steelhead trout (*O. mykiss*), sea-run cutthroat trout (*O. clarki*), white sturgeon (*Acipenser transmontanus*), green sturgeon (*A. medirostris*), and American shad (*Alosa sapidissima*). The primary forage fish resources are Northern anchovy (*Engraulis mordax*) and longfin smelt (*Spirinchus thaleichthys*).

CHINOOK SALMON

There is a continuum of chinook entry into Chehalis Basin streams from March through December. Chehalis Basin chinook salmon are managed as separate spring and fall runs. Spring chinook return between March 1 and August 31 to the Chehalis Indian net fishery in the vicinity of Oakville. Fall chinook begin entering the Satsop as early as September and return to other tributaries later. Fall chinook return to the Grays Harbor fisheries after September 1 (Stone, WDF, pers. comm.).

Terminal Area Run Size and Escapement Goals

__Spring Chinook__

Terminal area run size, that is, escapement plus Chehalis Basin catch, has been sufficient to meet the escapement goal in three of the past five years, although the goal was never met from 1970 to 1985 (Table 5; Figure 7).

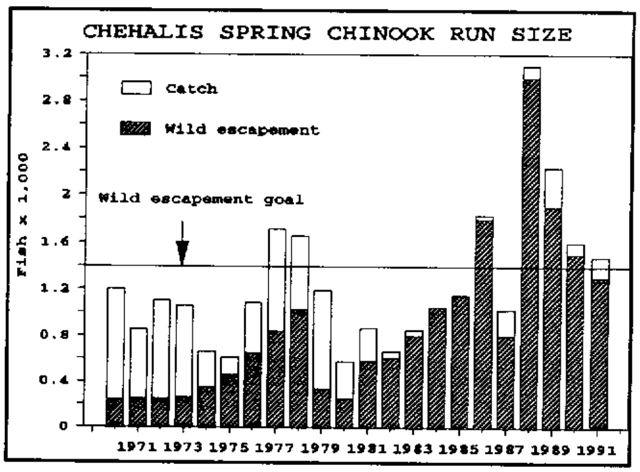

Figure 7. Chehalis Basin spring chinook salmon terminal area run size (WDF, unpublished data).

Drastic cutbacks in all fisheries, but particularly the Chehalis tribal fishery, may have contributed to recovery (Deschamps, Chehalis Tribe,; Stone, WDF, pers. comm.). Cyclical improvement in early marine survival since the 1983 *El Niño* event may also be contributing. Despite the overall increase in escapement, Wynoochee spring chinook are thought to be non-existent (Stone, WDF, pers. comm.); they were cited as at high risk of extinction by Nehlsen et al. (1991).

	Wild escapement goal met			Terminal run size	
	Goal	Last brood cycle[A]	Period of record[A]	Last brood cycle	Period of record[D]
Chinook					
Spring run	1,400	3/5	4/22	2,023	1,614
Fall run	14,600	4/5[B]	5/23	39,818	21,587
Coho	35,400	3/3	16/25	166,674	104,387
Chum	21,000	1/4	7/23	53,247	44,725
Steelhead					
Winter run					
Chehalis system					
Hatchery	C	C	C	4,884	4,405
Wild	8,600	1/4	5/9	11,032	11,779
Humptulips system					
Hatchery	C	C	C	1,395	2,841
Wild	1,600	4/4	8/8	4,152	4,412
Summer run	C	C	C	688	1,035

A. First number stands for number of years goal was met or exceeded; second number stands for number of years considered.
B. Disputed by QFiD, who claim escapement goal was met in all 5 most recent years
C. Meeting hatchery escapement goals is seldom a limiting factor in fishery management.
D. Periods of record are: spring chinook, 1970-1991; fall chinook, 1969-1991; coho, 1967-1991; chum, 1969-1991; Chehalis winter steelhead, 1982-83 to 1990-91; Humptulips winter steelhead, 1978-79 to 1990-91; summer steelhead 1981-1989.

Table 5. Chehalis Basin wild salmon and steelhead escapement goals and the number of years in which the escapement goal was recently met.

Fall Chinook

Although the wild escapement goal was never met from 1969 to 1983, runs have exceeded or met the goal for the last five years (Table 5, Figure 8) and parallel the positive trend for spring chinook. All the probable factors allowing spring chinook recovery are likely affecting fall chinook as well. Hatchery production is a small part of the Chehalis Basin fall run, apparently

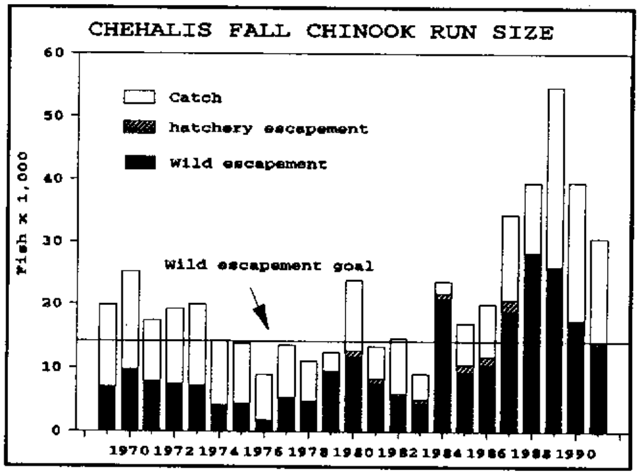

Figure 8. Chehalis Basin fall chinook terminal area run size (WDF unpublished data).

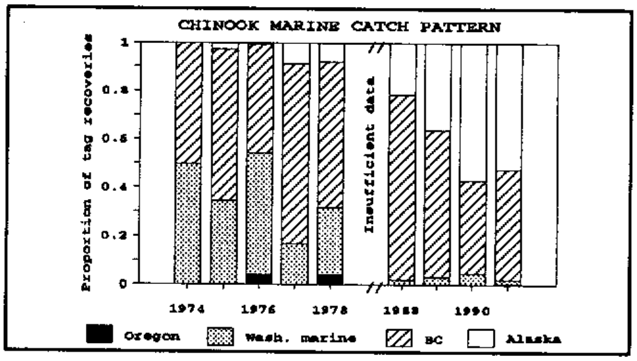

Figure 9. Fall chinook marine interception patterns (PFMC and WDF data).

because of poor post-release survival of Simpson Hatchery smolts (Brix, WDF, pers. comm.). Hatchery production has had relative success on the Humptulips, the difference possibly being due to the inner Harbor pollution block mentioned earlier.

Fall Chinook Marine Interception

Fall chinook are caught primarily in the ocean troll fisheries off southeast Alaska and northern British Columbia. British Columbia fisheries caught 68.9 percent of the Chehalis fall chinook marine catch throughout the period for which tag returns are available (Figure 9). The remaining marine catch went to Alaska, at 19.7 percent, and Washington at 11.2 percent.

Juvenile Chinook Production

Seiler *et al.* (1992a) enumerated the capture of chinook salmon in a floating inclined plane trap between Oakville and Rochester between 1985 and 1990. Estimates of emigration could not be made because trapping efficiency was not evaluated. The following table roughly indicates the weak relation between smolt abundance and the previous year's adult escapement upstream of Porter; little is actually known about the relation between adult escapement and smolt production.

Brood year	Adult escapement	Smolt catch
1985	2,826	17,337
1986	3,133	20,964
1987	5,034	39,164
1988	6,152	121,479
1989	5,628	10,002
1990	1,963	16,537

Current Fall Chinook Total Run Size and Historical Levels

Chehalis Basin chinook abundance is within the same order of magnitude as that reconstructed from historical catch data (Table 6), given the assumptions outlined below. This suggests current run size is a base level of natural production, to be reinforced by improving inner Harbor and upper Chehalis water quality, and by assuring optimum wild escapement through refinements in habitat assessment and fishery management. It is important that any hatchery programs be enhancement, not replacement, of the base level.

The following are assumptions supporting estimates of total chinook run size in Table 6.

I. HISTORIC PERIOD

The Grays Harbor Catch Reporting Area non-Indian gillnet catch, averaged over the period 1910-1919, plus present Chehalis Basin spring and fall chinook escapement is a conservative estimate of potential healthy total run size, based on the following assumptions:

A. **The Grays Harbor Catch Reporting Area represented the Chehalis Basin even though the Area included all the rivers of the northern Washington coast to Cape Flattery.** Catch records beginning in 1936 divided Grays Harbor Area catch into only two categories: Grays Harbor commercial gillnet catch, and north coastal Indian catch, thus implying that:
   1. North coastal non-Indian catch was negligible in comparison to north coastal Indian catch;
   2. the Grays Harbor Indian catch was negligible in comparison to the Grays Harbor non-Indian catch; and
   3. sport catch throughout the Area was negligible.

B. **The average catch from 1910 to 1919 represented a healthy run (following a method used by Chapman (1986) for the Columbia River.**
   1. The 10-year catch averaging period is the shortest that results in an easily interpreted catch trend because undue weight is not given to unusually high or low brood cycles.
   2. The Grays Harbor non-Indian gillnet catch trend increased from the initial 1890-1899 period, reached its highest value during the 1910-1919 period, and declined from then until now. This suggests:
      a. Fishing pressure increased to maximum efficiency until the peak period, and overfishing did not seriously affect the population prior to the start of catch reporting in 1890.
      b. Terminal area overfishing (Wendler and Deschamps 1955b) combined with the onset of splash dam logging (Wendler and Deschamps 1955a) initiated a stock decline after the peak catch period.
      c. Because marine interception became significant only after the peak period (Wendler and Deschamps 1955b), the peak period catch is still a reliable estimate of total catch, if one accepts that:
         1.) Washington marine catch represents coastal marine fishing effort in general; and
         2.) Washington marine fishing increased at the same rate prior to inception of marine catch records in 1936 (WDF 1971), as it did during its expansionary period thereafter, i.e., it was negligible prior to the 1920s.

C. **Average historical spawning escapements were similar to current escapements.**

II. CURRENT PERIOD

Estimated terminal catch plus marine catch plus spawning escapement, averaged over 1987-1990, reasonably estimates total wild run size of Chehalis Basin fall chinook, based on the following assumptions:

A. **The ratio of 1987-1990 marine area expanded tag returns to terminal area expanded tag returns multiplied by the terminal area catch, adequately estimates marine interception of Chehalis Basin chinook (Table 7).** This rests on four propositions:
   1. *Terminal tag recoveries represent all commercial salmon fisheries.* Any resulting upward bias in total catch would not be excessive since fall chinook sport catch averaged only about eight percent of the terminal area catch (WDF, unpublished data).

Current period

Catch year[B]	Escapement[C]	Terminal area wild fall run catch[A] Humptulips R.	Chehalis R.	Chehalis Basin
1987	18,850	4,878	7,517	
1988	28,150	7,376	3,610	
1989	26,100	11,320	18,294	
1990	17,500	7,978	13,457	
Mean	22,650	7,888	10,720	
Total catch/terminal catch[D]		1.60	4.07	
Estimated total catch		12,621	43,634	56,251
Estimated run size (catch plus escapement)				78,901

Historical period

Catch year[E]	Grays Harbor Area non-Indian gillnet catch[F]
1910	64,458
1911	50,269
1912	52,521
1913	84,647
1914	34,743
1915	43,885
1916	43,884
1917	49,460
1918	29,386
1919	26,946
Mean catch	48,020
Historic escapement[G]	+22,650
Estimated wild run average size	70,670

A. Source: WDF unpub. run reconstruction data provided by Dick Stone, Montesano.
B. Tag recovery data unavailable for prior years.
C. Source: WDF unpub. data. provided by Dick Stone, Montesano.
D. See Table 7.
E. See Table 8 for explanation of choice of base period.
F. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.
G. Assumed to be the same as current escapement.

Table 6. Estimation of historic and current Chehalis Basin wild chinook populations (see text for assumptions).

2. *Fall chinook interception represents Chehalis Basin chinook as a whole.* No tagging studies have been performed on Chehalis spring chinook, but they are assumed to have the same far-northerly distribution as coastal Washington chinook stocks in general (Fraidenburg 1982; Scott 1992 draft).
3. *Separate calculation for Humptulips and Chehalis systems adequately accounts for differing terminal exploitation rates due to heavier exploitation of Humptulips fall chinook than Chehalis fish* (WDF, unpublished data).
4. *Hatchery and wild fish contribute to marine and terminal fisheries in essentially the same way.* This is the accepted assumption in interpretation of PSC indicator stocks coastwide (Scott 1992 draft).

B. **Spring chinook catch was omitted from calculations for simplicity, because this fishery would have added an average of only about 200 fish to the Chehalis system catch.** Including this catch would also have added to the bias described in Item I.A.1. above.

Catch year	Origin	Expanded tag recoveries Che. basin	Marine	Ratio (Che.+Mar.)/Che.
1987	Simpson	3	19	
1988	Simpson	22	79	
1989	Simpson	31	158	
1990	Simpson	61	103	
Total		117	359	4.07
1987	Humptulips	154	32	
1988	Humptulips	129	51	
1989	Humptulips	75	83	
1990	Humptulips	129	124	
Total		487	290	1.60

Table 7. Tag recovery data used to expand terminal wild chinook catch to estimate total catch including interception.

COHO SALMON

Chehalis Basin coho are biologically divided into two groups based on spawn timing, but for fisheries management are treated as a single group (Stone, WDF, pers. comm.). The largest, "normal" spawn timing group consists of both hatchery and wild fish, which peaks in the Grays Harbor fishery in early October and spawn in early December throughout the Chehalis Basin. The later-spawning group is virtually all wild, returns in late November and December and spawns in January-February, primarily in the major lower Chehalis tributaries.

Terminal Area Run Size and Escapement Goals

Combined Normal- and Late-timed Spawners

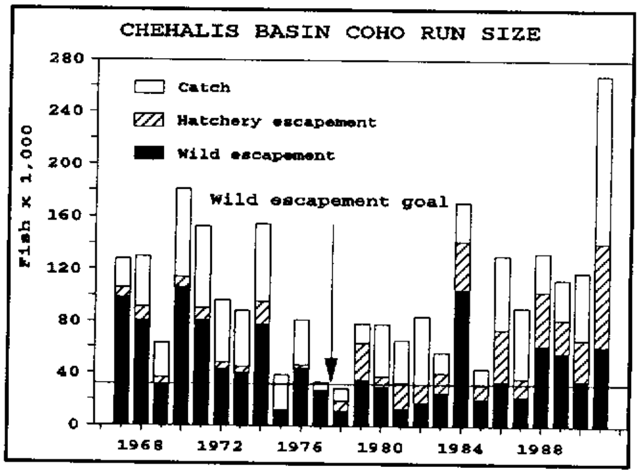

Figure 10. Chehalis Basin coho salmon terminal area run size (WDF unpublished data).

Although the terminal catch has been tending to increase, until recently wild escapement often fell short of the goal (Table 5). The wild escapement goal has been met in all four of the past years but was only met in eight of the past seventeen years; this despite increasing terminal runs over those years (Figure 10). Local underescapement is common even when the overall goal is met, although not consistent in any one sub-basin (Stone, WDF, pers. comm.). Wild underescapement may result from low survival of wild coho, sometimes combined with heavy harvest.

Late-timed Spawners

Late-spawning wild coho have been documented in Bingham Creek, a tributary of the East Fork Satsop (Dave Seiler, WDF, pers. comm.), the upper Wynoochee River (USACE, Seattle District, unpub. records), and the Wishkah River (Terry Balzell, LLTK, pers. comm.) and may use other streams as well (Seiler, WDF, pers. comm.). Late-spawning coho have always been far fewer than normal-timed coho, but the late run has been particularly small in the last several years, perhaps due to unintentionally heavy hatchery brood stocking or poor survival of late-timed hatchery coho after release (Seiler, WDF, pers. comm.).

Marine Interception

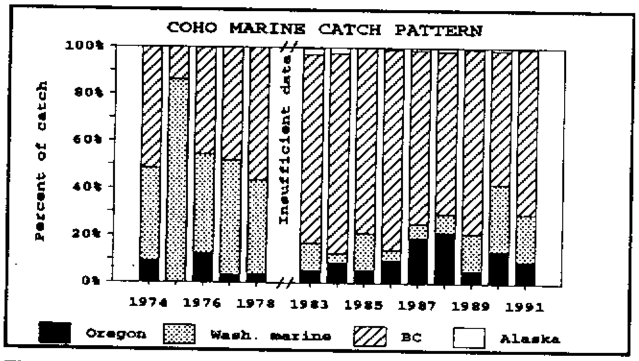

Figure 11. Chehalis Basin marine coho catch distribution (PSMFC and WDF unpublished data).

The British Columbia fisheries, mostly off the west coast of Vancouver Island, accounted for an average 82.7% of the marine catch of Chehalis coho salmon throughout the last 15 years (Figure 11). Oregon fishers harvested an average of 7.3%. The Washington share varied from 3.9 to 15.6%.

Juvenile Production

The number of natural coho smolts produced annually in the entire Chehalis Basin above the town of

Brood year	Escapement	Hatchery-reared fry release (brood year+1)	Low Flow index[A] (brood year+1)	Smolt Production (brood year+2)
1974	78,000	525,000		116,000
1975	10,000	90,000		47,000
1984	80,000	3,383,000	7.81	884,000
1985	8,000	3,700,000	6.02	400,000
1986	32,000	2,900,000	4.62	500,000
1987	18,800	2,500,000	7.57	225,000
1988	33,000	2,500,000	6.56	771,000
1989	30,000	2,700,000	8.05	300,000

A. Indicates summer low streamflow, an important limiting factor in coho smolt production.

Table 8. Juvenile coho production from the Upper Chehalis River system (Brix and Seiler 1977, 1978; Seiler et al. 1992b; WDF unpublished records).

Porter (Table 8) was estimated by trapping downstream migrants in 1976, 1977, and from 1986 to 1991 (Brix and Seiler 1977, 1978; Seiler *et al.* 1992b). The upper Chehalis is producing roughly as many coho smolts per square mile and per spawner as other western Washington streams (Seiler 1987, 1989). The upper Chehalis system produces exceptionally large, healthy smolts compared with several other western Washington rivers (Schroder and Fresh 1992).

Smolt production from the 1974 brood year was lower than other years perhaps because smolt trapping was not begun until April 15 (Brix and Seiler 1977), by which time some of the smolts had already migrated past the trap site, (Table 8) (Brix and Seiler 1978). Smolt production from the 1984 brood year corresponds to full seeding of the spawning grounds (Seiler 1987).

To estimate the total Chehalis Basin coho run size for an average water year, assuming the "pollution block" were removed, Seiler (1987) used the smolt production of Bingham Creek, where 5 years of trapping showed production averaged around 34,900 per year. Expanding this number in direct proportion to the number of accessible miles of stream in the upper Chehalis system suggested that the system would produce 1,000,000 smolts in a normal water year with adequate spawning. Since the upper Chehalis covers 920 square miles, and the whole Basin is 2,500 square miles, the Basin should produce two to three million smolts (Seiler 1987). At a 10 percent smolt-to-adult survival, this would create a total run -- that is, marine interception plus terminal run -- of 200,000 to 300,000 adults. This exceeds even the estimated historic high run size described below.

Catch year	Origin of tag group	Tags recovered from catch Marine[A]	Che. Basin[B]	Ratio (Mar.+Che.)/Che.
1984	Chehalis system wild	949	288	
	Humptulips system wild	452	63	
1985	Simpson Hatchery	311	142	
	Chehalis system wild	481	61	
1986	Chehalis system wild	1,083	540	
	Humptulips Hatchery	3,198	367	
	Humptulips system wild	682	56	
1987	Chehalis system wild	329	425	
1988	Simpson Hatchery	366	83	
	Humptulips Hatchery	1,702	296	
Total	Chehalis system	3,519	1,539	3.29
	Humptulips system	6,034	782	8.72

A. Sources: Pacific States Marine Fishery Commission database, September 1991 and Washington Department of Fisheries tag recovery publications.

B. Sources: Washington Department of Fisheries tag recovery publications and database, September 1991.

Table 9. Data used to calculate expansion factors for coho catch estimates.

Current Coho Run Size and Historical Levels

Table 9 indicates how the expansion factors for Chehalis Basin coho catches were calculated. The current Chehalis Basin wild coho population is about 135,000 fish, clearly less than the 229,000 reconstructed from historical catch data (Table 10). The current hatchery run size is about 131,000 (Table 11) so the combined wild and hatchery population of 266,000 appears to only slightly exceed the historical level. This suggests that hatchery production has replaced, not added to, natural production.

The rapidly increasing hatchery influence since the late 1970's, approaching half the total escapement in 1990, raises concern regarding the long-term adaptability of the total run to the Chehalis Basin.

Terminal tag recoveries may or may not represent all estuarine and river sport fisheries, depending on the year of recovery. The resulting tendency to overestimate total catch may be more substantial than for chinook, since coho sport catch averaged about 17.8 percent of the terminal area catch of Chehalis Basin coho (WDF, unpublished data).

Current period

Catch year[B]	Escapement[C]	Terminal area wild coho catch[A] Humptulips R.	Chehalis R.	Chehalis Basin
1984	104,617	3,416	16,647	
1985	20,643	1,779	5,500	
1986	33,683	6,359	28,954	
1987	22,642	2,734	36,625	
1988	41,003	2,839	4,441	
Mean	44,518	3,425	18,433	
Marine/terminal[D]		8.72	3.29	
Estimated total catch		29,866	60,645	90,511
Estimated run size (catch plus escapement)				135,029

Historical period

Catch year[E]	Grays Harbor Area non-Indian gillnet catch[F]
1905	158,783
1906	144,494
1907	128,769
1908	115,929
1909	118,753
1910	251,734
1911	388,104
1912	242,152
1913	89,257
1914	200,438
Mean catch	184,000
Historic wild escapement[G]	+44,518
Estimated wild run average size	228,518

A. Source: WDF unpub. run reconstruction data provided by Dick Stone, Montesano.
B. Tag recovery data unavailable for prior years.
C. Source: WDF unpub. data. provided by Dick Stone, Montesano.
D. See Table 9.
E. See Table 8 for explanation of choice of base period.
F. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.
G. Assumed to be the same as current escapement.

Table 10. Chehalis Basin estimated historical and current wild coho run sizes.

Catch year[B]	Escapement[A]	Terminal area hatchery coho catch[A] Humptulips system	Chehalis system	Chehalis Basin
1984	36,589	1,803	7,540	
1985	10,873	1,074	3,608	
1986	40,448	15,782	6,038	
1987	13,667	8,106	7,215	
1988	60,330	19,676	2,834	
Mean	32,381	9,288	5,447	
Marine/terminal[C]		8.72	3.29	
Est. total catch		80,991	17,921	98,912
Est. average run size				131,000

A Source: WDF unpublished run reconstruction data provided by Dick Stone.
B Tag recovery data unavailable for prior years.
C See Table 9.

Table 11. Chehalis Basin estimated hatchery coho catches and run size.

CHUM SALMON

Terminal Area Run Size and Escapement Goal

There are no known sub-stocks of chum salmon in the Chehalis Basin based on spawn timing or location. Run size has averaged 53,000 over the last four years (Table 5, Figure 12). The trend toward larger run sizes (Figure 12) may have to do with improving estuary rearing conditions or ocean survival. However, failure to meet the escapement goal has become more common in the past several years and may jeopardize sustained recovery. Adequate escapement, particularly with chum, depends on accurately predicting the terminal run size since virtually all catch is in the terminal area. Unfortunately, this is difficult due to unpredictable year-to-year differences in marine survival and age at return.

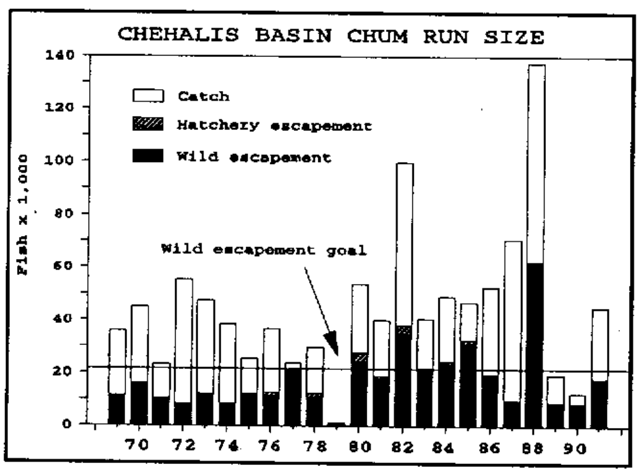

Figure 12. Chehalis Basin chum salmon terminal area run size (WDF unpublished data).

Current Run Size and Historical Levels

The Chehalis Basin chum population appears more depleted, compared to historical levels, than any other species (Table 12).

Current period

Catch year	Wild Escapement[A]	Chehalis Basin catch[A]
1981	18,050	20,900
1982	35,100	61,550
1983	21,000	18,700
1984	23,700	24,200
1985	31,300	14,200
1986	19,550	33,000
1987	9,500	60,950
1988	62,200	75,250
1989	9,100	10,411
1990	9,000	3,600
Mean	23,850	30,186
Estimated average run size		54,000

Historical period

Catch year	Grays Harbor Area non-Indian gillnet catch[B]
1910	134,616
1911	211,207
1912	200,687
1913	72,539
1914	132,724
1915	84,491
1916	84,490
1917	43,187
1918	27,750
1919	184,124
Mean	117,581
Current escapement	+23,850
Estimated average wild run size	141,000

A. Source: WDF unpub. data. provided by Dick Stone, Montesano.
B. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.

Table 12. Chehalis Basin historical and current chum salmon run sizes.

STEELHEAD

Terminal Area Run Size and Escapement Goals

Steelhead are managed separately as winter and summer runs (Bill Freymond, WDW pers. comm.). WDW defines winter run fish as those caught in the Chehalis Basin between November 1 and April 30. Summer steelhead are caught between May 1 and October 31 (WDW 1991a). Harvest management plans assume negligible marine interception in the coastal salmon fisheries (QFiD and WDW 1991).

Winter Run

Winter steelhead are managed for both hatchery and wild harvest except on certain upper Chehalis tributaries where sport fishing is regulated primarily to provide sufficient wild escapement (Freymond 1989). The dual goal of providing hatchery harvest opportunity while allowing wild escapement is supported, more so in the Humptulips system, by high early season harvest and lower late season harvest (QFiD and WDW 1991). This is possible because hatchery fish tend to return to the rivers earlier than wild fish, due to historical selection for early-returning fish (Royal 1972). Chehalis Basin hatchery fish follow this pattern to the degree that they were derived from Chambers Creek stock, and not from later-returning local brood stock (QFiD and WDW 1991). The greater timing separation and lower overall hatchery influence on the Humptulips coincides with consistent achievement of the wild escapement goal in that system compared to the Chehalis system (Figure 13).

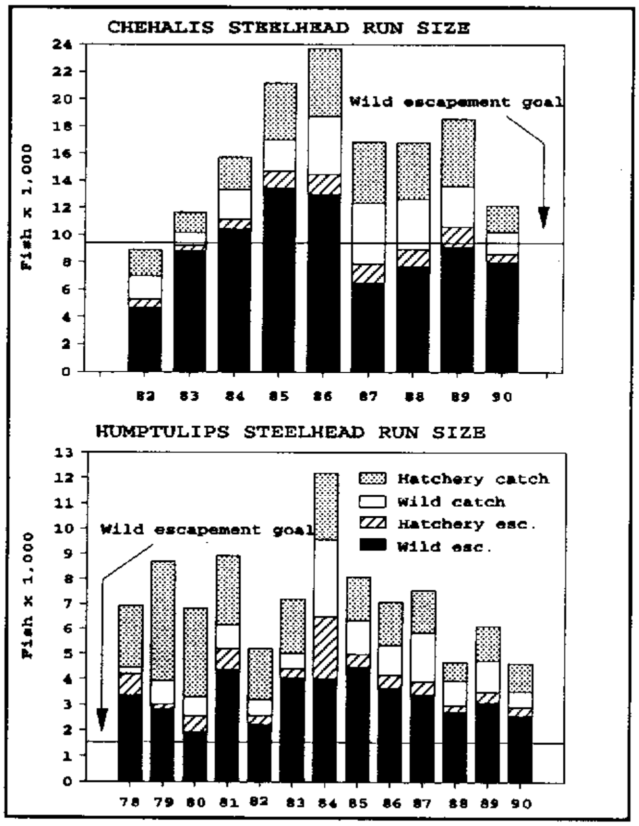

Figure 13. Chehalis and Humptulips steelhead run sizes (QFiD and WDW 1990).

Chehalis River System. Chehalis system runs have averaged about 11,000 hatchery fish over the last 3-year hatchery life cycle, and 13,000 wild fish over the last 4-year wild life cycle (Table 5). Wild escapement goals were met in five of the last eight years but only two of the last four (Table 5, Figure 13). Increased harvest of wild fish in the last several years coincides with decreased wild escapement. Hatchery programs expanded until 1985, and then remained roughly the same (Figure 13). An increase in winter steelhead releases into the Chehalis Basin is likely since the Aberdeen Hatchery will no longer be allowed to release fish outside the Chehalis Basin, due to disease considerations (Bob Paulsen, WDW, pers. comm.).

Humptulips River System. Humptulips runs have averaged about 1,700 hatchery fish over the last three years and 4,600 wild fish over the last four. The winter steelhead run appears to be in good condition, insofar as the wild escapement goal has been consistently exceeded (Table 5; Figure 13).

Hatchery programs have made up less of the run since 1985, due to quarantines of Lake Quinault and Quinault National Fish Hatchery stocks (Paul Huffman, Quinault Nation, pers. comm.). Hatchery contributions are expected to return to prior levels because of better hatchery techniques, use of conditioning ponds, and development of local Humptulips brood (Paul Huffman, Quinault Nation, pers. comm.).

Summer Run

Skamania-stock summer steelhead were introduced as a hatchery run in 1979 (Paulsen, pers. comm.). Runs have averaged about 700 adults over the last three years (Table 5), and have supported sport fisheries primarily on the Wynoochee and Humptulips, but to a lesser degree on the main stem Chehalis and Satsop rivers (Figure 14). The Wynoochee and Satsop catch has declined since the early 1980s, for unknown reasons (Paulsen, WDW, pers. comm.), and a decline on the Humptulips is due to shortage of brood stock at the Aberdeen Hatchery.

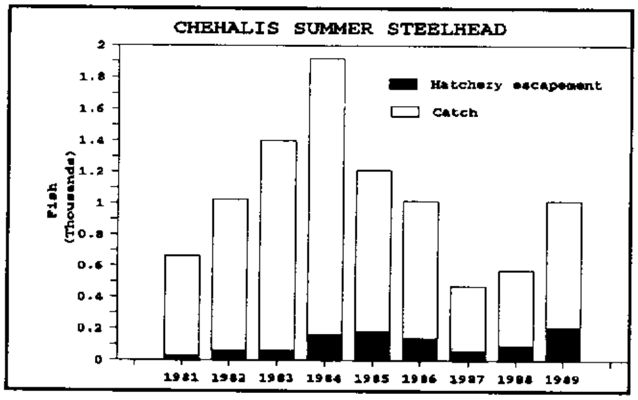

Figure 14. Chehalis Basin summer run steelhead.

Current Total Run Size and Historical Levels

The Grays Harbor non-Indian gillnet catch was at its highest during the 1894-1903 period, and declined from that period to 1935. This suggests that fishing pressure may have reached maximum efficiency before catch reporting began in 1894; thus, the base period estimate may be weaker than for salmon and may underestimate run size. For simplicity, summer steelhead were not included since they contribute a relatively small number of fish to the Chehalis Basin catch. Marine catch is negligible.

The average current wild steelhead run size is about 17,000 fish while the historic run size is estimated to have been about 20,000 (Table 13). Hatchery run size is currently about 7,000 (Table 5). While the Chehalis Basin wild winter steelhead population may be somewhat less than what it was historically, it falls into the same order of magnitude as that reconstructed from historical catch data (Table 13). This should be interpreted as a base level of natural production, to be reinforced by assuring optimum wild escapement through full utilization of all available habitat and refinements in fishery management. Any additional hatchery programs should be considered additional, rather than replacement, production.

Current period

Catch season	Escapement[A]	Catch[A]	Run size
1982-83	6,958	2,322	
1983-84	12,954	1,498	
1984-85	14,530	5,236	
1985-86	17,960	3,616	
1986-87	16,666	5,464	
1987-88	9,945	6,412	
1988-89	10,474	4,616	
1989-90	12,235	4,208	
Mean	12,715	4,172	17,000

Historical period

Catch year	Grays Harbor Area non-Indian gillnet catch[B]
1894	4,898
1896	6,817
1897	5,076
1898	11,620
1899	11,378
1900	7,092
1902	3,673
1903	4,898
Mean	6,932
Current escapement	12,715
Estimated wild run size	20,000

A. Source: QFiD and WDW (1991).

B. Source: WDF unpub. data. provided by Lee Hoines, WDF, Olympia.

Table 13. Estimation of historical and current Chehalis Basin wild winter steelhead run sizes.

STURGEON

Commercial catch of mixed white and green sturgeon increased from the 1940s, when catch recording began, peaked in 1964, declined to 1977, and now appears to be increasing slowly (Figure 15). It is thought that Grays Harbor catch represents a small part of a single spawning population centered around the Columbia River (Devore, WDF, pers. comm.). Two arguments support this: the migration of tagged sturgeon throughout the coastal area from Tillamook Bay to the Quileute River; and the scarcity of juveniles in most streams smaller than the Columbia River (Stone, WDF, pers. comm.; Devore, WDF, pers. comm.). The Lower Columbia population is considered healthy and not apparently density-dependent; that is, (1) nearly constant numbers of fish now reach fishable size each year, resulting in a population composed of fish of many ages, and (2) individual growth rates are relatively rapid, compared to other populations. Devore (WDF, pers. comm.) believes this implies that the habitat is close to being fully seeded.

White Sturgeon Population Status

This species supports the majority of both sport and commercial fisheries in the Chehalis Basin. In response to reduced stock size (Figure 15), management reduced harvest rates, which succeeded in reversing the decline and also increasing individual fish size. In particular, the directed commercial setline and gillnet fishery on the Columbia River has been eliminated, and commercial catch has been cut in half. Grays Harbor fisheries have also been more regulated and the July commercial fishery has been eliminated. The sport season remains open year-round (WDF 1992). Mathematical modeling indicates that the minimum and maximum sport size limits of 48 and 60 inches, effective both in the Chehalis Basin and on the Columbia River (WDF 1992), seem to be maintaining sustainable harvest and protecting spawning-sized females. Recent relatively level catches are thought to represent the optimum sustained yield (Stone, WDF, pers. comm.).

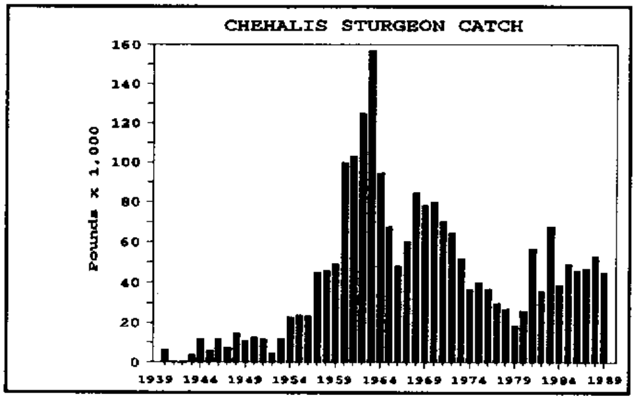

Figure 15. Chehalis Basin white and green sturgeon commercial landings.

Catches in Grays Harbor probably come predominantly from the Columbia River spawning stock, the only well-documented spawning population in Washington and Oregon, although there is much white surgeon habitat available for potential production in the Chehalis Basin in the form of cobbly riffles with high velocity (J. Devore, FWS, pers. comm.). A few juveniles, apparently a few months old, were seined from the main stem Chehalis during summer in the early 1970's (John Wolfe, FWS, pers. comm.). Wolfe believes white sturgeon historically occurred in the Chehalis up to the Newaukum.

WDF's policy is to promote exclusively natural production, at least until the potential for disease transmission in Columbia River experimental hatcheries has been brought to manageable levels through research and development, and the risk of genetic weakening through interbreeding with hatchery fish has been adequately assessed (Devore, WDF, pers. comm.).

Green Sturgeon Population Status

This species supports a small percentage of the commercial fisheries in Grays Harbor. It is not known to what degree green sturgeon caught in Grays Harbor originate from Grays Harbor as opposed to other river basins. Green sturgeon are suspected to spawn in estuaries throughout the northwest, and Grays Harbor is a likely spawning ground, along with Willapa Bay (Devore, WDF, pers. comm). Spawners do not migrate far upstream from tidewater, and occur in the Chehalis below Montesano. Green sturgeon are far fewer than whites, and there has been no accurate assessment of their population. Green sturgeon and white sturgeon are covered by the same fishing regulations.

AMERICAN SHAD

American shad (*Alosa sapidissima*) were introduced to the Pacific coast in 1871, 1885, and 1886 (Craig and Hacker 1940). The Grays Harbor shad catch very likely represents a local spawning stock, based on the high degree of homing tendency in Atlantic coast populations (Dadswell *et al.* 1987). Shad have been observed in the Chehalis River as far upstream as Rainbow Falls (RM 97), but the greatest concentration of shad spawning is likely near Rochester (Wolfe, FWS, pers. comm.). Young-of-the-year shad were captured from Montesano and points downstream; most apparently move downstream in August-October (WDF 1971). American shad juveniles and adults occurred frequently in experimental seine samples from the inner Harbor but never occurred in large numbers in any one sample (Simenstad and Eggers 1981).

The stock may have been depleted, because the first reported catch, in 1945, was much larger than that of any subsequent year (Figure 16). Few catches have been reported from the Grays Harbor Catch Reporting Area over the last ten years. Some caution is warranted, however, in using catches as the sole measure of stock success because 1) the weak market for shad may control reported catches, i.e., small catches may not be reported if they are never sold, and 2) decreases in shad catches could be due to spring chinook closures since shad are mainly captured incidentally to spring chinook.

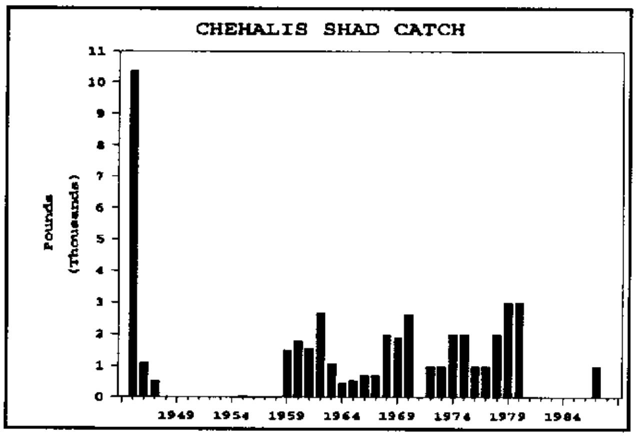

Figure 16. Chehalis Basin American shad commercial catch, 1945-1989 (Ward et al. 1970; WDF 1990).

Habitat problems for Chehalis Basin shad have not been identified, but it is known that shad recovery in the Delaware River coincided with reduction of point source pollution and consequent increases in dissolved oxygen (Maurice *et al.* 1987). In the Sacramento River, pollution was a potentially important shad stressor (Stevens *et al.* 1987). Juvenile shad are in the Chehalis during July and August, the time when water quality is at its worst.

FORAGE RESOURCES

Forage fish for salmon are not regulated in fishery management. Chinook and chum salmon juveniles prey upon larval northern anchovy in the deeper waters of Grays Harbor but do not use other baitfish species, even if other baitfish are relatively abundant (Simenstad and Eggers 1981). The authors found that northern anchovy were present from June through October, with adults occurring at Westport and juveniles at Moon Island and Cow Point; longfin smelt were prey for sea-run cutthroat trout in Grays Harbor from May through October.

Simenstad and Eggers (1981) gave evidence that standing stock of open-water zooplankton limits the population of juvenile salmonids in Grays Harbor. Sources of plankton are the Chehalis River downstream to Moon Island; the estuary itself, especially at Moon Island and Cow Point, and marine waters east to the vicinity of Stearns Bluff (Figure 2).

Regarding epibenthic zooplankton, Simenstad and Eggers (1981) concluded that (1) standing stocks may be critical to growth and survival of juvenile salmon; (2) juvenile salmonids fed selectively for sparsely distributed prey, which means the total area of shallow waters below the low tide line may limit the number of juvenile salmonids which can feed there; and (3) sources of productivity for bottom-dwelling prey of salmon were organic debris from the rivers, eelgrass beds, and saltmarshes, and diatom growth on the mudflats.

Chapter 4: HATCHERY PRODUCTION OF SALMONIDS

Fish culture originally had the goal of augmenting fish production to whatever degree might prove feasible, and later of compensating for the clearly harmful effects of splash dam logging (Grays Harbor Regional Planning Commission 1992). However, hatcheries can outlive their original purposes, and can in fact stimulate the evolution of fishery management. Stone (1989) described the main features of the WDF hatchery program in a speech to the Chehalis Basin Fishery Task Force. The following information represents his view of a general agreement among tribal and WDF staff:

> "Hatchery production is used to produce fish for harvest and brood stock for programs to supplement wild production through off-station releases, primarily of fingerlings. Hatchery harvest depends mainly on on-station coho releases. Hatchery coho returns to the Humptulips and Satsop rivers are managed to provide fishing opportunity in addition to natural production. The current management strategy is to take advantage of the earlier timing of hatchery coho in the Humptulips, and of the sport opportunity created by large numbers of hatchery coho in the Satsop. Future production may include adding fall chinook to the existing coho netpen program at the Westport Boat Basin".
>
> "Supplementation through off-station releases involves fall chinook as well as coho. Fall chinook supplementation involves the Humptulips, Mayr Brothers, Lake Aberdeen, and Satsop hatcheries, which provide holding and spawning for wild brood stock from the Humptulips, Wishkah, Wynoochee, and upper Chehalis rivers, respectively. Coho supplementation involves the Humptulips and Satsop hatcheries, which outplant hatchery stock fingerlings, although less extensively than in former years because the utility of this practice in being increasingly questioned".

On the same occasion, Freymond (1989) described the current WDW hatchery program:

> "Hatchery production is used to maintain existing opportunities for winter and summer steelhead harvest. Hatchery harvest depends on both on-station and off-station releases. The current management strategy in the Humptulips, Hoquiam, and Wishkah rivers is to take advantage of the earlier timing of hatchery winter steelhead for selective harvest of hatchery production. However, on the Wynoochee, Skookumchuck, and Newaukum rivers the strategy is to optimize survival by using native winter steelhead stock from the Aberdeen Hatchery and the Skookumchuck Dam".

HATCHERY HISTORY

When fish culture began in the 1890s, fish were regularly introduced from outside the Basin (Stone, WDF, pers. comm.). Around the turn of the century, the first local salmon hatcheries were built (Grays Harbor Regional Planning

Commission 1992). However, several decades elapsed before technical rearing practices allowed hatcheries to significantly contribute to the catch (Deschamps, quoted in GHRPC 1992). The principal remedy for logging abuses was thought to be hatcheries, primarily to produce coho fry for stocking upstream of reaches formerly blocked by splash dams; however, no scientific evaluation of these early activities was reported (Wendler and Deschamps 1955a).

In the late 1930s it became known that fish released as fry generally survived poorly to adult compared to larger fish that were ready to migrate to sea. This led to closure of all fry stations and construction of hatcheries capable of rearing fish to smolt size (Wendler and Deschamps 1955b).

In 1936, the WDG opened the Aberdeen Fish Hatchery on Lake Aberdeen (John Kugen, WDW, pers comm.). This was the first local hatchery capable of rearing fish to smolt size, resulting in much higher survival than had been possible before. This was followed for salmon in 1949, with the opening of Simpson Salmon Hatchery on the East Fork Satsop River (WDF, unpublished records).

In the 1960s, the Oregon Moist Pellet was introduced, apparently resulting in increased fish survival in hatcheries, which led to further hatchery expansion and higher adult contribution to the catch (Deschamps, quoted in GHRPC 1992).

The Satsop Springs facility, several miles downstream of Simpson Hatchery, was opened in 1963 as a chum eyed egg channel. In 1977, Satsop Springs was expanded and became operational as a major salmon rearing station in the early 1980s (Dick Stone, WDF, pers. comm.).

WDW began developing more local steelhead brood stocks in 1971 (Kugen, WDW, pers. comm.). The USACE built a barrier dam and fish trap at Wynoochee River RM 47.8, to collect adult salmon and trout and truck them upstream of Wynoochee Dam. WDW used the dam to capture local brood, taking steelhead to the Aberdeen Hatchery and allowing the surplus to be trucked upstream. In 1979, WDW broadened the base of local brood stocks by constructing a trap on Van Winkle Creek (Kugen, WDW, pers. comm.).

In 1975, the expansion of hatchery salmon influence continued as WDF opened the Humptulips Hatchery (WDF, unpublished records). This watershed formerly depended primarily on wild runs, although there had been an egg-taking station in the first half of the century and the system received extensive plantings of hatchery stocks prior to the hatchery opening.

In the same year, WDW began transporting steelhead smolts reared at Aberdeen to the Mayr Brothers Pond on the Wishkah for conditioning before release (Paul Huffman, Quinault Nation, pers. comm.). This pond has become a major cooperative rearing project among Long Live the Kings, WDF, WDW, and QfiD.

In 1977, WDF reported underseeding of natural coho habitat in the upper Chehalis, based on smolt trapping studies and estimates of available habitat (Brix and Seiler 1977, 1978). These studies led to extensive coho fry stocking, primarily from the Simpson Hatchery, to fully utilize upper Chehalis habitat (WDF, unpublished records).

Chinook and coho rearing ponds were added to the Satsop Springs facility in 1979 (Stone, WDF, pers. comm.).

In the early 1980s, Chehalis Basin production capacity was further increased when the WDF Skookumchuck Ponds opened below the Skookumchuck Dam (Stone, WDF, pers. comm.). However, these ponds were not constructed to mitigate for the dam, nor to provide fish for any specific area (Bruya 1990). Consequently, several years later, all coho from the Skookumchuck Ponds were released into southern Puget Sound via netpens, because smolts released there survived to adulthood much better than smolts released into the upper Chehalis (Stone, WDF, pers. comm.).

In 1988, the USACE supported Aberdeen Hatchery expansion to mitigate for nearly all annual losses of steelhead and cutthroat trout due to construction of the Wynoochee Dam. As a result, hatching space was approximately doubled to its present capacity of 1.65 million eggs (Kugen, WDW, pers. Comm.).

In 1991, WDF and WDW began making joint use of the Loomis Ponds and Humptulips Hatchery for both salmon and steelhead production (Paul Huffman, Quinault Indian Nation, pers. comm.).

HATCHERY STOCKS

Most hatchery stocks originated from local stocks then shifted to outside strains, but over the years there has been a move to develop 100 percent local, perhaps wild or native brood sources. The sustainability of hatchery production has recently been questioned by research in fish genetics (Miller 1990, Hindar *et al.* 1991, Johnsson and Abrahams 1991), behavior (Solazzi *et al.* 1990), and disease (Steward and Bjornn 1990). There has also recently been a shift to restricting hatchery stocks to within-basin transfers only (Bob Paulsen, WDW, pers. comm.) or even within sub-basins (Stone, WDF, pers. comm.). Most Chehalis Basin wild salmon and steelhead populations have had extensive outside influence, although few introductions have occurred within the last ten years (Stone, WDF, pers. comm.). The variety of stocks and facilities is listed below.

AVAILABLE BROOD STOCKS

Spring chinook

- Chehalis wild

Fall chinook

- Upper Chehalis wild
- Satsop hatchery
- Wishkah wild
- Humptulips wild

Coho

- Simpson hatchery
- Bingham Creek wild

Satsop Springs hatchery
Wynoochee Dam wild
Wishkah wild
Humptulips hatchery

Winter steelhead

Early run

VanWinkle Creek hatchery

Late run

Skookumchuck wild
Wynoochee Dam wild

Summer steelhead

VanWinkle Creek hatchery

Spring Chinook Salmon

Spring chinook have never been successfully propagated in a Chehalis Basin hatchery. Small-scale attempts to culture Skookumchuck spring chinook were made in the late 1970s, with only limited success because brood stock was difficult to collect and survival was poor. In 1977 and 1978, Cowlitz spring chinook were introduced into the Wynoochee (Stone, WDF, pers. comm.). QFiD personnel have intermittently found chinook with spring timing in the Wynoochee since 1987 (Chitwood, QFiD, pers. comm.). Now, with increasing emphasis on developing a year-round sport fishery, some parties propose restoring Wynoochee spring chinook with upper Chehalis stock (Dave Hamilton, CBFTF, pers. comm.).

Fall Chinook Salmon

Fall chinook hatchery brood stock was transferred from the Kalama in the 1890s, later from Green River via the Deschutes, then from the Elk and Trask Rivers of coastal Oregon in the early 1970's, and most recently, from the Willapa Hatchery in the late 1970's (Johnson and Longwill 1991). Most non-native introductions have been made to the Satsop and, for this reason, WDF does not now allow Satsop Hatchery fall chinook releases outside the Satsop drainage (Rick Brix, WDF, pers. comm.).

Coho Salmon

Coho hatchery brood stock have also come from numerous sources, beginning with introductions from the Kalama in the 1890s (Stone, WDF, pers. comm.). Fry releases from the Willapa Hatchery to the upper Chehalis have been frequent throughout the history of hatchery production (Stone, WDF, pers. comm.). Quileute summer coho were also used on one occasion. The latest import was Hoodsport stock in the early 1980s. Unlike fall chinook, coho introductions have been spread throughout the Basin, so no efforts are now made to confine current releases to one area (Brix, WDF, pers. comm.).

Chum Salmon

Chum introductions have been infrequent. Willapa and Hoodsport stock were brought to the Satsop Hatchery in the mid-1970's (Stone, WDF, pers. comm.). Chum production now depends entirely on natural production because hatchery programs were not clearly successful (Stone 1989).

Winter Run Steelhead

Winter steelhead stocks from outside the Basin were historically used but introductions decreased as hatcheries developed local brood stock sources. Chambers Creek winter stock was released widely in the upper Chehalis beginning in 1936 (WDW unpublished records). These records also show that many releases were made from the Mossyrock Hatchery in the lower Columbia drainage starting in 1943, that sporadic introductions from the Puyallup Ponds were made starting in 1977, and that Bogachiel stock (which originated at Chambers Creek) has been used since 1982. More recently, Cook Creek stock from Quinault National Fish Hatchery was released into the Humptulips.

Native brood stock now supports programs that release smolts at Skookumchuck Dam and Aberdeen Hatchery (Freymond 1989), and a local winter steelhead brood stock is being developed at the Humptulips and Mayr Brothers hatcheries (Huffman, Quinault Nation, pers. comm.).

Summer Run Steelhead

The first recorded summer steelhead release was made in 1926 by the WDG from the Washougal Hatchery on the lower Columbia (Kugen, WDW, pers. comm.). No further introductions are on record until 1974, when summer steelhead from Skamania Hatchery were released from Aberdeen Hatchery (WDW unpublished records). These records show that releases of lower Columbia stock became routine in the Wynoochee and Humptulips rivers by 1980, when the WDW Aberdeen Hatchery had developed a local population, derived from Skamania stock, in Van Winkle Creek.

Increasing pressure to develop a year-round sport fishery focused renewed attention on summer steelhead introductions, because no local brood stock was apparent (Harry Senn, pers. comm.). Harvest is managed exclusively for hatchery production (Bob Paulsen, WDW, pers. comm.). Wild steelhead release regulations are in effect June 30 through November 1 in all Chehalis Basin streams to protect naturally produced summer steelhead.

Other Salmonids

In addition to these intensely managed species, cutthroat trout and resident rainbow trout have been released from many non-Chehalis sources. However, sea-run cutthroat trout hatchery programs have increasingly used local brood stock since 1983; Jay Hunter (WDW, pers. comm.) lists Skookumchuck, Elk, Johns, and Wishkah rivers and Chenois Creek as brood stock sources.

HATCHERY FACILITIES AND PRACTICES

Since their creation, hatcheries have tended toward improved rearing efficiency and more hatcheries and satellite stations as illustrated in table below. Over the years, emphasis has changed from off-station to on-station releases, and from fry to smolt release.

FISH CULTURE FACILITIES

Within the Basin

- South Fork Newaukum:
  - Merryman's Ponds (Onalaska School) -- coho
- North Fork Newaukum:
  - Cole's Pond -- steelhead
- Skookumchuck:
  - Skookumchuck Ponds -- coho
  - PP&L/WDW ponds -- steelhead
- Main stem Satsop River:
  - Mitchell Creek Pond -- sea-run cutthroat trout
  - Muller Hatchery -- coho
- East Fork Satsop:
  - Simpson Hatchery -- fall chinook, coho
  - Satsop Springs -- fall chinook, coho, chum
- Van Winkle Creek:
  - Aberdeen Hatchery -- winter and summer steelhead; sea-run cutthroat trout; coho and chinook
- Wishkah River:
  - Mayr Brothers Hatchery -- fall chinook, winter steelhead
- Humptulips River:
  - Loomis Ponds -- winter steelhead
  - Humptulips Hatchery -- fall chinook, coho, winter steelhead
- Inner Grays Harbor:
  - Hoquiam Netpens -- coho
- Outer Grays Harbor:
  - Westport Netpens -- coho
  - Ocean Shores Netpens -- coho

Outside Chehalis Basin but often used to stock steelhead in Chehalis Basin

- WDW Chambers Creek near Tacoma
- WDW Mossy Rock State Hatchery
- WDW Puyallup Ponds
- WDW Shelton Hatchery
- USFWS Quinault National Fish Hatchery at Cook Creek
- Washougal Hatchery (Skamania stock summer steelhead)

Construction contemplated

- Chehalis Tribal Hatchery on Cedar Creek -- fall chinook, spring chinook, coho, chum, winter steelhead

Rehabilitation contemplated

- Outer Grays Harbor: Sea Farms of Norway at Westport -- species undetermined
- Wynoochee: Briscoe Ponds -- fall chinook

Hatcheries were usually not sited or sized to make up for a specified amount of local habitat damage, nor to restore populations to a particular level. Only in the last two decades have such concepts begun to be accepted. Rather, hatcheries were expected to increase total catch as much as possible. In that sense, coho and steelhead efforts were successful throughout the Basin, and fall chinook were successful on the Humptulips. Chum enhancement has not noticeably increased catch anywhere in the system and has been discontinued (Dick Stone, WDF, pers. comm.). Sea-run cutthroat releases have been extensive but never evaluated (Jay Hunter, WDW, pers. comm.).

Some believe hatcheries pose a danger to natural fish production unless the program is carefully designed and managed (Oregon Trout 1990; Hilborn 1992). Investment in a hatchery leads to demand for efficient harvest of hatchery fish, which may overharvest intermingled wild fish (Bakke 1987), unless the hatchery program provides for harvest at a separate time or place. Importation of an exotic hatchery stock, or artificial selection for favorable hatchery traits using a native stock, may decrease fitness of natural spawners if these cross with hatchery-reared strays (Hindar *et al.* 1987). Hatchery fish released at an improper time, place, size, or number can competitively displace naturally produced fish (Solazzi *et al.* 1990). Finally, hatcheries may serve as incubators of disease and magnify their effect on wild fish (Goodman 1990). Proper management can reduce or avoid most of these effects, but the general theme of recent research is that every existing or proposed hatchery should have specific goals, safeguards, and evaluation for compatibility with the native stock with which it shares a gene pool.

HATCHERY FISH PRODUCTION

Species/run	Percent hatchery fish		
	Entire Chehalis Basin	Chehalis System	Humptulips System
Summer steelhead[A]	100.0	100.0	100.0
Coho	43.5	31.2	71.6
Winter steelhead	29.8	29.0	31.9
Fall chinook	4.4	B	13.7
Chum	1.8	C	C
Spring chinook	0.0	0.0	0.0

A There is probably some limited summer steelhead natural reproduction but the amount is undetermined.
B There is some contribution from cooperative rearing projects but it is presently unquantified.
C Data not available.

Table 14. Hatchery contributions to Chehalis Basin anadromous salmonid runs (WDF and WDW unpublished data; QFiD and WDW 1990).

Several early Chehalis Basin hatcheries produced an annual average of 300,000 chinook fry and one million coho fry in the Basin between 1905 and 1938 (Wendler and Deschamps 1955b). This program was considered ineffective even in its day, in view of continued declines in catches.

During the last two decades, hatchery production has increased overall, although more so in some species than others. Coho and steelhead hatchery programs are now reasonably successful, contributing about 40 and 30 percent to the Chehalis Basin catches of each species, respectively (Table 14). On the other hand, fall chinook and chum programs have not made significant contributions despite long-standing hatchery programs. Hatchery production accounts for most of the summer steelhead catch, but this run contributes a very small number of fish to the total catch. Success of extensive cutthroat trout releases is impossible to determine, since it has not been evaluated.

Fall Chinook Salmon

Fall chinook production has been erratic, although smolt production has increased over the last two decades (Figure 17) and has largely replaced fry releases. The Satsop River hatchery program began before 1970 but production was discontinued in 1979 due to dwindling numbers of adults returning to the Simpson Hatchery (WDF unpublished records). In 1987, production was resumed using the Satsop Springs facility for adult capture and rearing and the Simpson facility for hatching. The Humptulips River program began in 1975 and suffered a similar shortage of brood stock. Although the hatchery goal until 1991 was to take one million eggs annually, typical egg-takes in the last brood cycle have been under 150,000, because adult fish do not readily enter the hatchery; the program will continue with an egg-take goal of 500,000 (Mark Kimball, WDF, pers. comm.). On-station releases are given priority at all hatcheries, since they appear to survive better than off-station releases (Stone, WDF, pers. comm.).

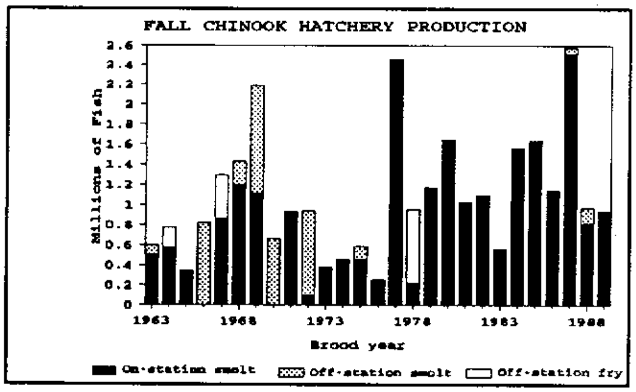

Figure 17. Hatchery-reared fall chinook released into the Chehalis Basin (WDF unpublished data).

Coho Salmon

Coho production at Simpson Hatchery increased (Figure 18), first in mitigation for the Skookumchuck Dam, and later in response to concerns about underseeding (Brix and Seiler 1977, 1978). Fry and fingerlings in excess of hatchery capacity are outplanted to many sites in the upper Chehalis system. On-station smolt releases have also increased over the last decade.

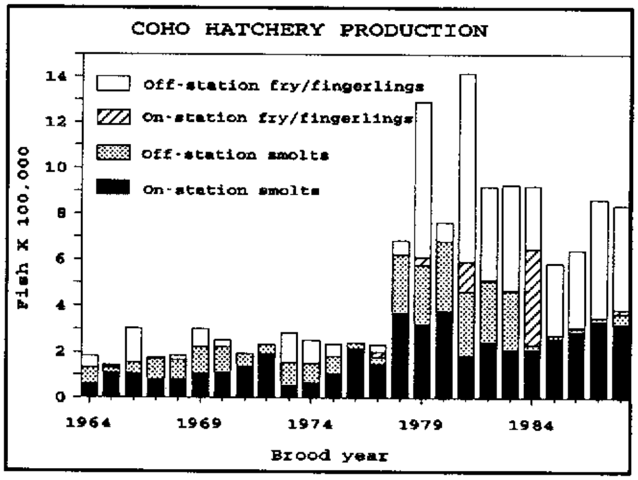

Figure 18. Hatchery-reared coho releases into the Chehalis Basin (WDF unpublished data).

Chum Salmon

The modern hatchery chum program began at Simpson Hatchery in 1965. Releases were particularly heavy between 1978 and 1982 (Figure 19). The last chum returning to the hatchery was recorded in 1987, and production was discontinued at that point (WDF unpublished records).

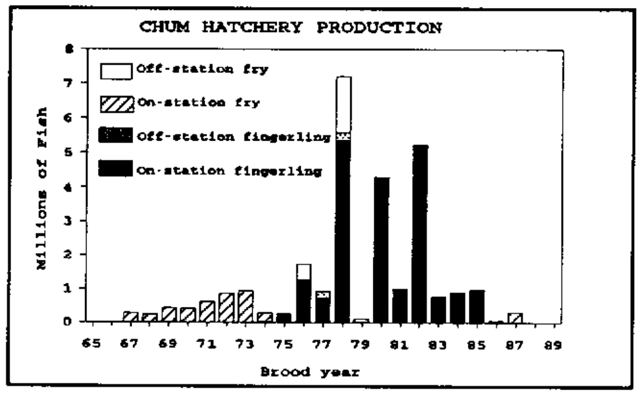

Figure 19. Hatchery-reared chum salmon released into the Chehalis Basin (WDF unpublished data).

Winter Steelhead

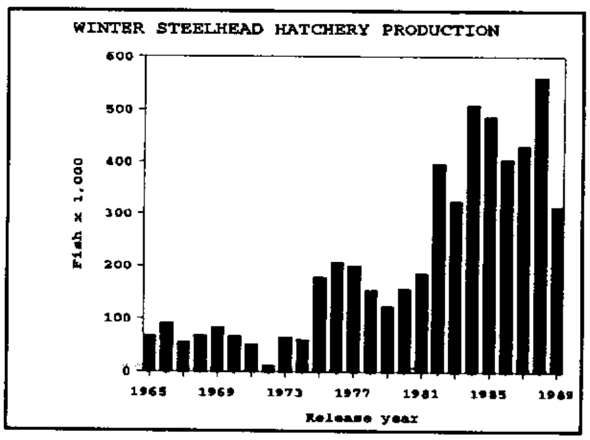

Figure 20. Hatchery-reared winter steelhead released into the Chehalis Basin (WDW unpublished data).

Winter-run steelhead production has been emphasized in hatchery programs. Small numbers were released annually since the early 1950s, but the program has grown since 1970 (Figure 20). In 1975, on-station releases became a significant part of production, and continue to make up about a third of each year's releases.